'Learning Mathematics through Games Series: 1. Why Games?' printed from http://nrich.maths.org/

We all know that children enjoy playing games. Experience tells us that games can be very productive learning activities. But ...

- What should teachers say when asked to educationally justify the use of games in mathematics lessons?
- Are some games better than others?
- What educational benefits are there to be gained from games?

This article supplies teachers with information that may be useful in better understanding the nature of games and their role in teaching and learning mathematics.

What is a mathematical game?

When considering the use of games for teaching mathematics, educators should distinguish between an 'activity' and a 'game'. Gough (1999) states that "A 'game' needs to have two or more players, who take turns, each competing to achieve a 'winning' situation of some kind, each able to exercise some choice about how to move at any time through the playing". The key idea in this statement is that of 'choice'. In this sense, something like Snakes and Ladders is NOT a game because winning relies totally on chance. The players make no decisions, nor do they have to think further than counting. There is also no interaction between players - nothing that one player does effects other players' turns in any way.

Oldfield (1991) says that mathematical games are 'activities' which:

- involve a challenge, usually against one or more opponents;
- are governed by a set of rules and have a clear underlying structure;
- normally have a distinct finishing point;
- have specific mathematical cognitive objectives.

Benefits of Using Games

The advantages of using games in a mathematical program have been summarized in an article by Davies (1995) who researched the literature available at the time.

- Meaningful situations - for the application of mathematical skills are created by games
- Motivation - children freely choose to participate and enjoy playing
- Positive attitude - Games provide opportunities for building self-concept and developing positive attitudes towards mathematics, through reducing the fear of failure and error;
- Increased learning - in comparison to more formal activities, greater learning can occur through games due to the increased interaction between children, opportunities to test intuitive ideas and problem solving strategies

- Different levels - Games can allow children to operate at different levels of thinking and to learn from each other. In a group of children playing a game, one child might be encountering a concept for the first time, another may be developing his/her understanding of the concept, a third consolidating previously learned concepts
- Assessment - children's thinking often becomes apparent through the actions and decisions they make during a game, so the teacher has the opportunity to carry out diagnosis and assessment of learning in a non-threatening situation
- Home and school - Games provide 'hands-on' interactive tasks for both school and home
- Independence - Children can work independently of the teacher. The rules of the game and the children's motivation usually keep them on task.

Few *language barriers* - an additional benefit becomes evident when children from non-English-speaking backgrounds are involved. The basic structures of some games are common to many cultures, and the procedures of simple games can be quickly learned through observation. Children who are reluctant to participate in other mathematical activities because of language barriers will often join in a game, and so gain access to the mathematical learning as well as engage in structured social interaction.

Hints for Successful Classroom Games

These tips come from Alridge & Badham (1993):

- Make sure the game matches the mathematical objective
- Use games for specific purposes, not just time-fillers
- Keep the number of players from two to four, so that turns come around quickly
- The game should have enough of an element of chance so that it allows weaker students to feel that they a chance of winning
- Keep the game completion time short
- Use five or six 'basic' game structures so the children become familiar with the rules - vary the mathematics rather than the rules
- Send an established game home with a child for homework
- Invite children to create their own board games or variations of known games.

Future articles in this series will cover types of games and creating your own games.

References

Aldridge, S. & Badham, V. (1993). Beyond just a game. *Pamphlet Number 21* . Primary Mathematics Association.
Davies, B. (1995). The role of games in mathematics. *Square One* . Vol.5. No. 2
Gough, J. (1999). Playing mathematical games: When is a game not a game? *Australian Primary Mathematics Classroom.* Vol 4. No.2
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'Learning Mathematics Through Games Series: 4. from Strategy Games' printed from http://nrich.maths.org/

There are several educationally useful ways of incorporating games into mathematics lessons. Games can be used as lesson or topic starters that introduce a concept that will then be dealt with in other types of activities. Some games can be used to explore mathematical ideas or develop mathematical skills and processes and therefore be a main component of a lesson. Perhaps the most common use of games is for practice and consolidation of concepts and skills that have already been taught. Yet another way to use games is to make them the basis for mathematical investigations.

Basic Strategy Games

Basic strategy games are particularly suitable as starting points for investigations because players instinctively try to discover a winning strategy, and usually the best way to do this is to analyze the outcomes of series of 'moves'. With a little encouragement from the teacher, a mathematical investigation is born. A few questions at the appropriate time will open up the task for the children and lead to some good quality mathematical thinking.

For example, a basic version of the ancient game of NIM can be used to start an investigation.

NIM
Make a pile of seven counters. Two players each take turns to remove either one or two counters from the pile. The player left with last counter is the loser.

Invite the children to play the game several times and they are sure to begin searching for winning strategies without being prompted. Ask whether it matters who goes first and encourage them to record moves. Opponents will soon become partners in investigation as they test their theories.
The teacher's role then is to get the children to explain and justify their strategy and so 'teach' or convince someone else. Now the game has been mastered it will no longer be enjoyable. It is time for a "What if??" question.
What happens if you start the game with a different number of counters? (A series of key numbers will emerge, as well as some interesting observations about odds and evens and multiples).

Problem-Solving Skills

Analyzing a game in this way will typically engage the student in some highly desirable problem solving strategies and processes: -

- being systematic,
- transforming information, (e.g. inventing a method for recording moves),
- searching for patterns,
- applying mathematics (calculations, algebra),

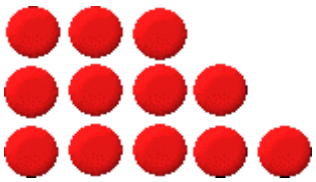
- manipulating variables,
- working backwards, simplifying the problem,
- hypothesizing and testing, and
- generalizing (perhaps even producing a formula)

What if you can take a different number of counters away?

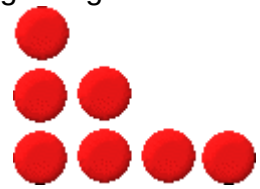
Variations of the Same Game

A way to take the investigation further and hence the mathematics further is to introduce a variation of the game and search for winning strategies.

NIM 3, 4, 5
Make a row of 3 counters, a row of 4 and a row of 5. Two players each take turns to remove any number of counters from a particular row. The player left with the last counter is the loser (or winner, as agreed at the start).

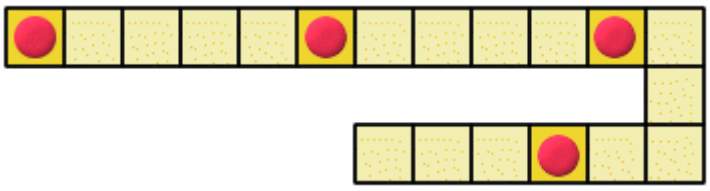


It might be helpful to suggest simplifying this game to a configuration of seven counters.



This may help them realize the importance of groups of two of four in the analysis.
It is often the case that problems and puzzles that appear to be quite different have a very similar underlying mathematical structure. This can also be the case for strategy games.

SLIDE *(Linear NIM)*
Place a counter on each of the four colored squares. Two players take turns to move any counter one, two or three spaces, until they reach the end of the track and are removed. No jumping is allowed. The winner (or loser as agreed) is the person left with sliding the last counter of the track.



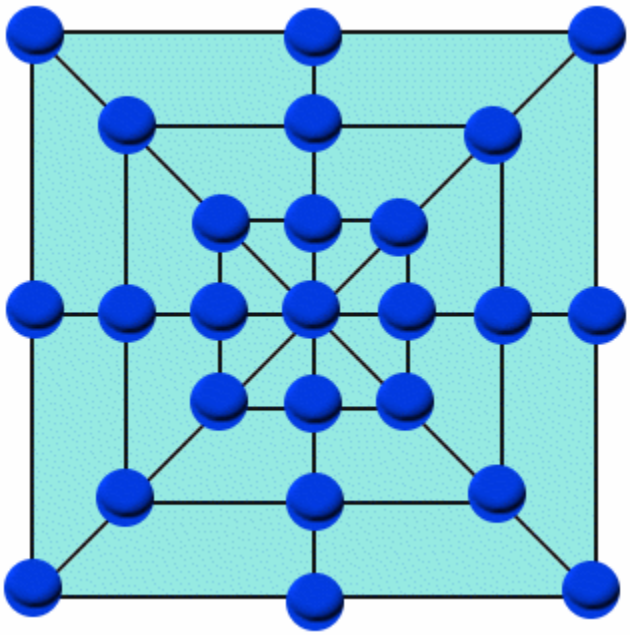
To analyze the game, it is helpful to start by playing it with only one counter, then two, then

three. Clear strategies can be found with one counter, but the introduction of other counters allows blocking, which complicates the moves.

How can what has been discovered about these games be used t o *create new challenging games?*

The NIM game can also be extended into a two-dimensional game board.

MINIM *(2-D NIM)*
Place twenty-five counters on the game board as shown. Players take turns to remove one or more counters that are side-by-side (no spaces between) on a straight line. The last player to take a counter is the loser.



Though complete analysis is too difficult, continuous scoring will help focus attention on early moves. (1 point for each counter removed, minus 5 for the last counter). Encourage the children to think backwards form the final move to discover helpful strategies towards the end of the game.

More Games?

All the games published monthly on the NRICH site are accompanied by questions that prompt mathematical thinking and investigations. Visit the games archive to find them.

An excellent source for groups of related strategy games is a book called "Strategy Games" by R. Sheppard and J. Wilkinson. It is published by Tarquin and available through their website.